

## Appendix A

Hardware Description in the Verilog language of a coder for coding data with the minimum pulse width of 2 sample periods and a maximum period between transitions of 22 sample periods.

```

5      //-----
//  

//      file: coder_16B24B.v  

//  

10     //      this is model of 16 to 24 bits encoder.  

//  

//  

//      revision history:  

//  

15     //      14/08/2003 initial release. (ia)  

//-----  

  

module CODER(  

      D,                                     // Data in  

20      Q);                                // data output  

  

      input      [7:0] D;  

      output     [11:0] Q;  

  

25      reg      [11:0] Q;  

  

      always @ (D) case (D)  

        8'h00   : begin Q <= 12'b000000000000; end  

        8'h01   : begin Q <= 12'b100000000000; end  

30        8'h02   : begin Q <= 12'b110000000000; end  

        8'h03   : begin Q <= 12'b011000000000; end  

        8'h04   : begin Q <= 12'b111000000000; end  

        8'h05   : begin Q <= 12'b001100000000; end  

        8'h06   : begin Q <= 12'b011100000000; end  

35        8'h07   : begin Q <= 12'b111100000000; end  

        8'h08   : begin Q <= 12'b000110000000; end  

        8'h09   : begin Q <= 12'b100110000000; end  

        8'h0A   : begin Q <= 12'b001110000000; end  

        8'h0B   : begin Q <= 12'b011110000000; end

```

```

8'h0C  : begin Q <= 12'b111110000000; end
8'h0D  : begin Q <= 12'b0000011000000; end
8'h0E  : begin Q <= 12'b1000011000000; end
8'h0F  : begin Q <= 12'b1100011000000; end
5      8'h10  : begin Q <= 12'b0000111000000; end
8'h11  : begin Q <= 12'b1001111000000; end
8'h12  : begin Q <= 12'b0011111000000; end
8'h13  : begin Q <= 12'b0111110000000; end
8'h14  : begin Q <= 12'b1111110000000; end
10    8'h15  : begin Q <= 12'b0000001100000; end
8'h16  : begin Q <= 12'b1000001100000; end
8'h17  : begin Q <= 12'b1100001100000; end
8'h18  : begin Q <= 12'b0110001100000; end
8'h19  : begin Q <= 12'b1110001100000; end
15    8'h1A  : begin Q <= 12'b0000011100000; end
8'h1B  : begin Q <= 12'b1000011100000; end
8'h1C  : begin Q <= 12'b1100011100000; end
8'h1D  : begin Q <= 12'b0000111100000; end
8'h1E  : begin Q <= 12'b1001111000000; end
20    8'h1F  : begin Q <= 12'b0011111000000; end
8'h20  : begin Q <= 12'b0111111000000; end
8'h21  : begin Q <= 12'b1111111000000; end
8'h22  : begin Q <= 12'b0000000110000; end
8'h23  : begin Q <= 12'b1000000110000; end
25    8'h24  : begin Q <= 12'b1100000110000; end
8'h25  : begin Q <= 12'b0110000110000; end
8'h26  : begin Q <= 12'b1110000110000; end
8'h27  : begin Q <= 12'b0011000110000; end
8'h28  : begin Q <= 12'b0111000110000; end
30    8'h29  : begin Q <= 12'b1111000110000; end
8'h2A  : begin Q <= 12'b0000001110000; end
8'h2B  : begin Q <= 12'b1000001110000; end
8'h2C  : begin Q <= 12'b1100001110000; end
8'h2D  : begin Q <= 12'b0110001110000; end
35    8'h2E  : begin Q <= 12'b1110001110000; end
8'h2F  : begin Q <= 12'b0000011110000; end
8'h30  : begin Q <= 12'b1000011110000; end
8'h31  : begin Q <= 12'b1100011110000; end
8'h32  : begin Q <= 12'b000111110000; end

```

```

8'h33  : begin Q <= 12'b100111110000; end
8'h34  : begin Q <= 12'b001111110000; end
8'h35  : begin Q <= 12'b011111110000; end
8'h36  : begin Q <= 12'b111111110000; end
5      8'h37  : begin Q <= 12'b000000011000; end
8'h38  : begin Q <= 12'b100000011000; end
8'h39  : begin Q <= 12'b110000011000; end
8'h3A  : begin Q <= 12'b011000011000; end
8'h3B  : begin Q <= 12'b111000011000; end
10    8'h3C  : begin Q <= 12'b001100011000; end
8'h3D  : begin Q <= 12'b011100011000; end
8'h3E  : begin Q <= 12'b111100011000; end
8'h3F  : begin Q <= 12'b000110011000; end
8'h40  : begin Q <= 12'b100110011000; end
15    8'h41  : begin Q <= 12'b001110011000; end
8'h42  : begin Q <= 12'b011110011000; end
8'h43  : begin Q <= 12'b111110011000; end
8'h44  : begin Q <= 12'b0000000111000; end
8'h45  : begin Q <= 12'b1000000111000; end
20    8'h46  : begin Q <= 12'b1100000111000; end
8'h47  : begin Q <= 12'b0110000111000; end
8'h48  : begin Q <= 12'b1110000111000; end
8'h49  : begin Q <= 12'b0011000111000; end
8'h4A  : begin Q <= 12'b0111000111000; end
25    8'h4B  : begin Q <= 12'b1111000111000; end
8'h4C  : begin Q <= 12'b0000001111000; end
8'h4D  : begin Q <= 12'b1000001111000; end
8'h4E  : begin Q <= 12'b1100001111000; end
8'h4F  : begin Q <= 12'b0110001111000; end
30    8'h50  : begin Q <= 12'b1110001111000; end
8'h51  : begin Q <= 12'b0000011111000; end
8'h52  : begin Q <= 12'b1000011111000; end
8'h53  : begin Q <= 12'b1100011111000; end
8'h54  : begin Q <= 12'b0000111111000; end
35    8'h55  : begin Q <= 12'b1001111111000; end
8'h56  : begin Q <= 12'b0011111111000; end
8'h57  : begin Q <= 12'b0111111111000; end
8'h58  : begin Q <= 12'b1111111111000; end
8'h59  : begin Q <= 12'b0000000001100; end

```

```

8'h5A  : begin Q <= 12'b100000001100; end
8'h5B  : begin Q <= 12'b110000001100; end
8'h5C  : begin Q <= 12'b011000001100; end
8'h5D  : begin Q <= 12'b111000001100; end
5      8'h5E  : begin Q <= 12'b001100001100; end
8'h5F  : begin Q <= 12'b011100001100; end
8'h60  : begin Q <= 12'b111100001100; end
8'h61  : begin Q <= 12'b000110001100; end
8'h62  : begin Q <= 12'b100110001100; end
10    8'h63  : begin Q <= 12'b001110001100; end
8'h64  : begin Q <= 12'b011110001100; end
8'h65  : begin Q <= 12'b111110001100; end
8'h66  : begin Q <= 12'b000011001100; end
8'h67  : begin Q <= 12'b100011001100; end
15    8'h68  : begin Q <= 12'b110011001100; end
8'h69  : begin Q <= 12'b000111001100; end
8'h6A  : begin Q <= 12'b100111001100; end
8'h6B  : begin Q <= 12'b001111001100; end
8'h6C  : begin Q <= 12'b011111001100; end
20    8'h6D  : begin Q <= 12'b111111001100; end
8'h6E  : begin Q <= 12'b000000011100; end
8'h6F  : begin Q <= 12'b100000011100; end
8'h70  : begin Q <= 12'b110000011100; end
8'h71  : begin Q <= 12'b011000011100; end
25    8'h72  : begin Q <= 12'b111000011100; end
8'h73  : begin Q <= 12'b001100011100; end
8'h74  : begin Q <= 12'b011100011100; end
8'h75  : begin Q <= 12'b111100011100; end
8'h76  : begin Q <= 12'b000110011100; end
30    8'h77  : begin Q <= 12'b100110011100; end
8'h78  : begin Q <= 12'b001110011100; end
8'h79  : begin Q <= 12'b011110011100; end
8'h7A  : begin Q <= 12'b111110011100; end
8'h7B  : begin Q <= 12'b000000011100; end
35    8'h7C  : begin Q <= 12'b100000011100; end
8'h7D  : begin Q <= 12'b110000011100; end
8'h7E  : begin Q <= 12'b011000011100; end
8'h7F  : begin Q <= 12'b111000011100; end
8'h80  : begin Q <= 12'b001100011100; end

```

```

8'h81  : begin Q <= 12'b011100111100; end
8'h82  : begin Q <= 12'b111100111100; end
8'h83  : begin Q <= 12'b000001111100; end
8'h84  : begin Q <= 12'b100001111100; end
5      8'h85  : begin Q <= 12'b110001111100; end
8'h86  : begin Q <= 12'b011001111100; end
8'h87  : begin Q <= 12'b111001111100; end
8'h88  : begin Q <= 12'b000011111100; end
8'h89  : begin Q <= 12'b100011111100; end
10    8'h8A  : begin Q <= 12'b110011111100; end
8'h8B  : begin Q <= 12'b000111111100; end
8'h8C  : begin Q <= 12'b100111111100; end
8'h8D  : begin Q <= 12'b001111111100; end
8'h8E  : begin Q <= 12'b011111111100; end
15    8'h8F  : begin Q <= 12'b111111111100; end
8'h90  : begin Q <= 12'b000000000110; end
8'h91  : begin Q <= 12'b100000000110; end
8'h92  : begin Q <= 12'b110000000110; end
8'h93  : begin Q <= 12'b011000000110; end
20    8'h94  : begin Q <= 12'b111000000110; end
8'h95  : begin Q <= 12'b001100000110; end
8'h96  : begin Q <= 12'b011100000110; end
8'h97  : begin Q <= 12'b111100000110; end
8'h98  : begin Q <= 12'b000110000110; end
25    8'h99  : begin Q <= 12'b100110000110; end
8'h9A  : begin Q <= 12'b001110000110; end
8'h9B  : begin Q <= 12'b011110000110; end
8'h9C  : begin Q <= 12'b111110000110; end
8'h9D  : begin Q <= 12'b000011000110; end
30    8'h9E  : begin Q <= 12'b100011000110; end
8'h9F  : begin Q <= 12'b110011000110; end
8'hA0  : begin Q <= 12'b000111000110; end
8'hA1  : begin Q <= 12'b100111000110; end
8'hA2  : begin Q <= 12'b001111000110; end
35    8'hA3  : begin Q <= 12'b011111000110; end
8'hA4  : begin Q <= 12'b111111000110; end
8'hA5  : begin Q <= 12'b000001100110; end
8'hA6  : begin Q <= 12'b100001100110; end
8'hA7  : begin Q <= 12'b110001100110; end

```

```

8'hA8  : begin Q <= 12'b011001100110; end
8'hA9  : begin Q <= 12'b111001100110; end
8'hAA  : begin Q <= 12'b000011100110; end
8'hAB  : begin Q <= 12'b100011100110; end
5      8'hAC  : begin Q <= 12'b110011100110; end
8'hAD  : begin Q <= 12'b000111100110; end
8'hAE  : begin Q <= 12'b100111100110; end
8'hAF  : begin Q <= 12'b001111100110; end
8'hB0  : begin Q <= 12'b011111100110; end
10    8'hB1  : begin Q <= 12'b111111100110; end
8'hB2  : begin Q <= 12'b000000001110; end
8'hB3  : begin Q <= 12'b100000001110; end
8'hB4  : begin Q <= 12'b110000001110; end
8'hB5  : begin Q <= 12'b011000001110; end
15    8'hB6  : begin Q <= 12'b111000001110; end
8'hB7  : begin Q <= 12'b001100001110; end
8'hB8  : begin Q <= 12'b011100001110; end
8'hB9  : begin Q <= 12'b111100001110; end
8'hBA  : begin Q <= 12'b000110001110; end
20    8'hBB  : begin Q <= 12'b100110001110; end
8'hBC  : begin Q <= 12'b001110001110; end
8'hBD  : begin Q <= 12'b011110001110; end
8'hBE  : begin Q <= 12'b111110001110; end
8'hBF  : begin Q <= 12'b000011001110; end
25    8'hC0  : begin Q <= 12'b100011001110; end
8'hC1  : begin Q <= 12'b110011001110; end
8'hC2  : begin Q <= 12'b000111001110; end
8'hC3  : begin Q <= 12'b100111001110; end
8'hC4  : begin Q <= 12'b001111001110; end
30    8'hC5  : begin Q <= 12'b011111001110; end
8'hC6  : begin Q <= 12'b111111001110; end
8'hC7  : begin Q <= 12'b000000011110; end
8'hC8  : begin Q <= 12'b100000011110; end
8'hC9  : begin Q <= 12'b110000011110; end
35    8'hCA  : begin Q <= 12'b011000011110; end
8'hCB  : begin Q <= 12'b111000011110; end
8'hCC  : begin Q <= 12'b001100011110; end
8'hCD  : begin Q <= 12'b011100011110; end
8'hCE  : begin Q <= 12'b111100011110; end

```

```

8'hCF  : begin Q <= 12'b000110011110; end
8'hD0  : begin Q <= 12'b100110011110; end
8'hD1  : begin Q <= 12'b001110011110; end
8'hD2  : begin Q <= 12'b011110011110; end
5      8'hD3  : begin Q <= 12'b111110011110; end
8'hD4  : begin Q <= 12'b000000111110; end
8'hD5  : begin Q <= 12'b100000111110; end
8'hD6  : begin Q <= 12'b110000111110; end
8'hD7  : begin Q <= 12'b011000111110; end
10    8'hD8  : begin Q <= 12'b111000111110; end
8'hD9  : begin Q <= 12'b001100111110; end
8'hDA  : begin Q <= 12'b011100111110; end
8'hDB  : begin Q <= 12'b111100111110; end
8'hDC  : begin Q <= 12'b000001111110; end
15    8'hDD  : begin Q <= 12'b100001111110; end
8'hDE  : begin Q <= 12'b110001111110; end
8'hDF  : begin Q <= 12'b011001111110; end
8'hE0  : begin Q <= 12'b111001111110; end
8'hE1  : begin Q <= 12'b000011111110; end
20    8'hE2  : begin Q <= 12'b100011111110; end
8'hE3  : begin Q <= 12'b110011111110; end
8'hE4  : begin Q <= 12'b000111111110; end
8'hE5  : begin Q <= 12'b100111111110; end
8'hE6  : begin Q <= 12'b001111111110; end
25    8'hE7  : begin Q <= 12'b011111111110; end
8'hE8  : begin Q <= 12'b111111111110; end
default : begin Q <= 12'hxxx; end
      endcase
30  endmodule

module CODER_16B24B(
      DA,                      // Data in lane A
      DB,                      // Data in lane B
35      P,                      // Polarity
      Q);                     // data output

input  [8:0] DA;           // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane A
input  [8:0] DB;           // {CMD,BH,BG,BF,BE,BD,BC,BB,BA} lane B

```

```

input          P;      //
output [23:0] Q;      // B{l,k,j,h,g,f,i,e,d,c,b,a} A{l,k,j,h,g,f,i,e,d,c,b,a}

reg          [23:0] Q;

5
//-----
// internal signals:
//-----

10  wire          va;
    wire          vb;
    wire [11:0] qa;
    wire [11:0] qb;
    wire [5:0]  ra;
15  wire [5:0]  rb;
    reg [7:0]  sa;
    reg [7:0]  sb;
    reg [23:0] qr;

20
//-----
// code:
//-----

25  assign va = DA >= 232;
    assign vb = DB >= 232;
    assign ra = DA - 232;
    assign rb = DB - 232;

30  always @ (DA or DB or va or vb) begin
    if (va) begin
        sa <= {ra,DB[1:0]};
        sb <= {DB[8:2],1'b0};
    end
    else if (vb) begin
        sa <= {rb,DA[1:0]};
35    sb <= {DA[8:2],1'b1};
    end
    else begin
        sa <= DA[7:0] + 1;
    end

```

```
    sb <= DB[7:0] + 1;  
  end  
end  
  
5  CODER CA(.D(sa), .Q(qa));  
  CODER CB(.D(sb), .Q(qb));  
  
always @ (qa or qb or va or vb) qr <= {{12{(va || vb)^qa[0]}}^qb, qa[0],  
  qa[1], qa[2], qa[3], qa[4], qa[5], qa[6], qa[7], qa[8], qa[9], qa[10], qa[11]};  
10 always @ (P or qr) Q <= {24{P^qr[0]}}^qr;  
  
endmodule
```

Appendix B

Hardware Description in the Verilog language of a decoder for coding data with the minimum pulse width of 2 sample periods and a maximum period between transitions of 22 sample periods.

```

5
-----
//-----  

//-----  

//      file: decoder_16B24B.v  

10 //-----  

//      this is model of 24 to 16 bits decoder.  

//-----  

//-----  

//      revision history:  

15 //-----  

//      14/08/2003 initial release. (ia)  

//-----  

-----  

module DECODER(  

20      D,                                     // Data in  

           Q);                                    // data output  

  

      input  [11:0] D;  

      output [7:0] Q;  

25
      reg      [7:0] Q;  

  

      always @ (D) case (D)  

30          12'b00000000000000 : begin Q <= 8'h00; end  

          12'b10000000000000 : begin Q <= 8'h01; end  

          12'b11000000000000 : begin Q <= 8'h02; end  

          12'b01100000000000 : begin Q <= 8'h03; end  

          12'b11100000000000 : begin Q <= 8'h04; end  

          12'b00110000000000 : begin Q <= 8'h05; end  

35          12'b01110000000000 : begin Q <= 8'h06; end  

          12'b11110000000000 : begin Q <= 8'h07; end  

          12'b00011000000000 : begin Q <= 8'h08; end  

          12'b10011000000000 : begin Q <= 8'h09; end  

          12'b00111000000000 : begin Q <= 8'h0A; end

```

```

12'b011110000000 : begin Q <= 8'h0B; end
12'b111110000000 : begin Q <= 8'h0C; end
12'b000011000000 : begin Q <= 8'h0D; end
12'b100011000000 : begin Q <= 8'h0E; end
5 12'b110011000000 : begin Q <= 8'h0F; end
12'b000111000000 : begin Q <= 8'h10; end
12'b100111000000 : begin Q <= 8'h11; end
12'b001111000000 : begin Q <= 8'h12; end
12'b011111000000 : begin Q <= 8'h13; end
10 12'b111111000000 : begin Q <= 8'h14; end
12'b000001100000 : begin Q <= 8'h15; end
12'b100001100000 : begin Q <= 8'h16; end
12'b110001100000 : begin Q <= 8'h17; end
12'b011001100000 : begin Q <= 8'h18; end
15 12'b111001100000 : begin Q <= 8'h19; end
12'b000011100000 : begin Q <= 8'h1A; end
12'b100011100000 : begin Q <= 8'h1B; end
12'b110011100000 : begin Q <= 8'h1C; end
12'b000111100000 : begin Q <= 8'h1D; end
20 12'b100111100000 : begin Q <= 8'h1E; end
12'b001111100000 : begin Q <= 8'h1F; end
12'b011111100000 : begin Q <= 8'h20; end
12'b111111100000 : begin Q <= 8'h21; end
12'b000000110000 : begin Q <= 8'h22; end
25 12'b100000110000 : begin Q <= 8'h23; end
12'b110000110000 : begin Q <= 8'h24; end
12'b011000110000 : begin Q <= 8'h25; end
12'b111000110000 : begin Q <= 8'h26; end
12'b001100110000 : begin Q <= 8'h27; end
30 12'b011100110000 : begin Q <= 8'h28; end
12'b111100110000 : begin Q <= 8'h29; end
12'b000001110000 : begin Q <= 8'h2A; end
12'b100001110000 : begin Q <= 8'h2B; end
12'b110001110000 : begin Q <= 8'h2C; end
35 12'b011001110000 : begin Q <= 8'h2D; end
12'b111001110000 : begin Q <= 8'h2E; end
12'b000011110000 : begin Q <= 8'h2F; end
12'b100011110000 : begin Q <= 8'h30; end
12'b110011110000 : begin Q <= 8'h31; end

```

```

12'b000111110000 : begin Q <= 8'h32; end
12'b100111110000 : begin Q <= 8'h33; end
12'b001111110000 : begin Q <= 8'h34; end
12'b011111110000 : begin Q <= 8'h35; end
5 12'b111111110000 : begin Q <= 8'h36; end
12'b000000011000 : begin Q <= 8'h37; end
12'b100000011000 : begin Q <= 8'h38; end
12'b110000011000 : begin Q <= 8'h39; end
12'b011000011000 : begin Q <= 8'h3A; end
10 12'b111000011000 : begin Q <= 8'h3B; end
12'b001100011000 : begin Q <= 8'h3C; end
12'b011100011000 : begin Q <= 8'h3D; end
12'b111100011000 : begin Q <= 8'h3E; end
12'b000110011000 : begin Q <= 8'h3F; end
15 12'b100110011000 : begin Q <= 8'h40; end
12'b001110011000 : begin Q <= 8'h41; end
12'b011110011000 : begin Q <= 8'h42; end
12'b111110011000 : begin Q <= 8'h43; end
12'b000000111000 : begin Q <= 8'h44; end
20 12'b100000111000 : begin Q <= 8'h45; end
12'b110000111000 : begin Q <= 8'h46; end
12'b011000111000 : begin Q <= 8'h47; end
12'b111000111000 : begin Q <= 8'h48; end
12'b001100111000 : begin Q <= 8'h49; end
25 12'b011100111000 : begin Q <= 8'h4A; end
12'b111100111000 : begin Q <= 8'h4B; end
12'b000001111000 : begin Q <= 8'h4C; end
12'b100001111000 : begin Q <= 8'h4D; end
12'b110001111000 : begin Q <= 8'h4E; end
30 12'b011001111000 : begin Q <= 8'h4F; end
12'b111001111000 : begin Q <= 8'h50; end
12'b000011111000 : begin Q <= 8'h51; end
12'b100011111000 : begin Q <= 8'h52; end
12'b110011111000 : begin Q <= 8'h53; end
35 12'b000111111000 : begin Q <= 8'h54; end
12'b100111111000 : begin Q <= 8'h55; end
12'b001111111000 : begin Q <= 8'h56; end
12'b011111111000 : begin Q <= 8'h57; end
12'b111111111000 : begin Q <= 8'h58; end

```

```

12'b000000001100 : begin Q <= 8'h59; end
12'b100000001100 : begin Q <= 8'h5A; end
12'b110000001100 : begin Q <= 8'h5B; end
12'b011000001100 : begin Q <= 8'h5C; end
5 12'b111000001100 : begin Q <= 8'h5D; end
12'b001100001100 : begin Q <= 8'h5E; end
12'b011100001100 : begin Q <= 8'h5F; end
12'b111100001100 : begin Q <= 8'h60; end
12'b000110001100 : begin Q <= 8'h61; end
10 12'b100110001100 : begin Q <= 8'h62; end
12'b001110001100 : begin Q <= 8'h63; end
12'b011110001100 : begin Q <= 8'h64; end
12'b111110001100 : begin Q <= 8'h65; end
12'b000011001100 : begin Q <= 8'h66; end
15 12'b100011001100 : begin Q <= 8'h67; end
12'b110011001100 : begin Q <= 8'h68; end
12'b000111001100 : begin Q <= 8'h69; end
12'b100111001100 : begin Q <= 8'h6A; end
12'b001111001100 : begin Q <= 8'h6B; end
20 12'b011111001100 : begin Q <= 8'h6C; end
12'b111111001100 : begin Q <= 8'h6D; end
12'b000000011100 : begin Q <= 8'h6E; end
12'b100000011100 : begin Q <= 8'h6F; end
12'b110000011100 : begin Q <= 8'h70; end
25 12'b011000011100 : begin Q <= 8'h71; end
12'b111000011100 : begin Q <= 8'h72; end
12'b001100011100 : begin Q <= 8'h73; end
12'b011100011100 : begin Q <= 8'h74; end
12'b111100011100 : begin Q <= 8'h75; end
30 12'b000110011100 : begin Q <= 8'h76; end
12'b100110011100 : begin Q <= 8'h77; end
12'b001110011100 : begin Q <= 8'h78; end
12'b011110011100 : begin Q <= 8'h79; end
12'b111110011100 : begin Q <= 8'h7A; end
35 12'b000000111100 : begin Q <= 8'h7B; end
12'b100000111100 : begin Q <= 8'h7C; end
12'b110000111100 : begin Q <= 8'h7D; end
12'b011000111100 : begin Q <= 8'h7E; end
12'b111000111100 : begin Q <= 8'h7F; end

```

```

12'b001100111100 : begin Q <= 8'h80; end
12'b011100111100 : begin Q <= 8'h81; end
12'b111100111100 : begin Q <= 8'h82; end
12'b000001111100 : begin Q <= 8'h83; end
5 12'b100001111100 : begin Q <= 8'h84; end
12'b110001111100 : begin Q <= 8'h85; end
12'b011001111100 : begin Q <= 8'h86; end
12'b111001111100 : begin Q <= 8'h87; end
12'b000011111100 : begin Q <= 8'h88; end
10 12'b100011111100 : begin Q <= 8'h89; end
12'b110011111100 : begin Q <= 8'h8A; end
12'b000111111100 : begin Q <= 8'h8B; end
12'b100111111100 : begin Q <= 8'h8C; end
12'b001111111100 : begin Q <= 8'h8D; end
15 12'b011111111100 : begin Q <= 8'h8E; end
12'b111111111100 : begin Q <= 8'h8F; end
12'b000000000110 : begin Q <= 8'h90; end
12'b100000000110 : begin Q <= 8'h91; end
12'b110000000110 : begin Q <= 8'h92; end
20 12'b011000000110 : begin Q <= 8'h93; end
12'b111000000110 : begin Q <= 8'h94; end
12'b001100000110 : begin Q <= 8'h95; end
12'b011100000110 : begin Q <= 8'h96; end
12'b111100000110 : begin Q <= 8'h97; end
25 12'b000110000110 : begin Q <= 8'h98; end
12'b100110000110 : begin Q <= 8'h99; end
12'b001110000110 : begin Q <= 8'h9A; end
12'b011110000110 : begin Q <= 8'h9B; end
12'b111110000110 : begin Q <= 8'h9C; end
30 12'b000011000110 : begin Q <= 8'h9D; end
12'b100011000110 : begin Q <= 8'h9E; end
12'b110011000110 : begin Q <= 8'h9F; end
12'b000111000110 : begin Q <= 8'hA0; end
12'b100111000110 : begin Q <= 8'hA1; end
35 12'b001111000110 : begin Q <= 8'hA2; end
12'b011111000110 : begin Q <= 8'hA3; end
12'b111111000110 : begin Q <= 8'hA4; end
12'b000001100110 : begin Q <= 8'hA5; end
12'b100001100110 : begin Q <= 8'hA6; end

```

```

12'b110001100110 : begin Q <= 8'hA7; end
12'b011001100110 : begin Q <= 8'hA8; end
12'b111001100110 : begin Q <= 8'hA9; end
12'b000011100110 : begin Q <= 8'hAA; end
5 12'b100011100110 : begin Q <= 8'hAB; end
12'b110011100110 : begin Q <= 8'hAC; end
12'b000111100110 : begin Q <= 8'hAD; end
12'b100111100110 : begin Q <= 8'hAE; end
12'b001111100110 : begin Q <= 8'hAF; end
10 12'b011111100110 : begin Q <= 8'hB0; end
12'b111111100110 : begin Q <= 8'hB1; end
12'b000000001110 : begin Q <= 8'hB2; end
12'b100000001110 : begin Q <= 8'hB3; end
12'b110000001110 : begin Q <= 8'hB4; end
15 12'b011000001110 : begin Q <= 8'hB5; end
12'b111000001110 : begin Q <= 8'hB6; end
12'b001100001110 : begin Q <= 8'hB7; end
12'b011100001110 : begin Q <= 8'hB8; end
12'b111100001110 : begin Q <= 8'hB9; end
20 12'b000110001110 : begin Q <= 8'hBA; end
12'b100110001110 : begin Q <= 8'hBB; end
12'b001110001110 : begin Q <= 8'hBC; end
12'b011110001110 : begin Q <= 8'hBD; end
12'b111110001110 : begin Q <= 8'hBE; end
25 12'b000011001110 : begin Q <= 8'hBF; end
12'b100011001110 : begin Q <= 8'hC0; end
12'b110011001110 : begin Q <= 8'hC1; end
12'b000111001110 : begin Q <= 8'hC2; end
12'b100111001110 : begin Q <= 8'hC3; end
30 12'b001111001110 : begin Q <= 8'hC4; end
12'b011111001110 : begin Q <= 8'hC5; end
12'b111111001110 : begin Q <= 8'hC6; end
12'b000000011110 : begin Q <= 8'hC7; end
12'b100000011110 : begin Q <= 8'hC8; end
35 12'b110000011110 : begin Q <= 8'hC9; end
12'b011000011110 : begin Q <= 8'hCA; end
12'b111000011110 : begin Q <= 8'hCB; end
12'b001100011110 : begin Q <= 8'hCC; end
12'b011100011110 : begin Q <= 8'hCD; end

```

```

12'b111100011110 : begin Q <= 8'hCE; end
12'b000110011110 : begin Q <= 8'hCF; end
12'b100110011110 : begin Q <= 8'hD0; end
12'b001110011110 : begin Q <= 8'hD1; end
5 12'b011110011110 : begin Q <= 8'hD2; end
12'b111110011110 : begin Q <= 8'hD3; end
12'b000000111110 : begin Q <= 8'hD4; end
12'b100000111110 : begin Q <= 8'hD5; end
12'b110000111110 : begin Q <= 8'hD6; end
10 12'b011000111110 : begin Q <= 8'hD7; end
12'b111000111110 : begin Q <= 8'hD8; end
12'b001100111110 : begin Q <= 8'hD9; end
12'b011100111110 : begin Q <= 8'hDA; end
12'b111100111110 : begin Q <= 8'hDB; end
15 12'b000001111110 : begin Q <= 8'hDC; end
12'b100001111110 : begin Q <= 8'hDD; end
12'b110001111110 : begin Q <= 8'hDE; end
12'b011001111110 : begin Q <= 8'hDF; end
12'b111001111110 : begin Q <= 8'hE0; end
20 12'b000011111110 : begin Q <= 8'hE1; end
12'b100011111110 : begin Q <= 8'hE2; end
12'b110011111110 : begin Q <= 8'hE3; end
12'b000111111110 : begin Q <= 8'hE4; end
12'b100111111110 : begin Q <= 8'hE5; end
25 12'b001111111110 : begin Q <= 8'hE6; end
12'b011111111110 : begin Q <= 8'hE7; end
12'b111111111110 : begin Q <= 8'hE8; end
default : begin Q <= 8'hxx; end
endcase
30
endmodule

module DECODER_16B24B(
35          D,           // Data in
          QA,          // data output lane A
          QB);         // data output lane B

input  [23:0] D;           // B{l,k,j,h,g,f,i,e,d,c,b,a} A{l,k,j,h,g,f,i,e,d,c,b,a}
output [8:0] QA;          // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane A

```

```

output  [8:0] QB;           // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane B

reg      [8:0] QA;
reg      [8:0] QB;
5
//-----
// internal signals:
//-----

10  wire  [8:0] s;
    wire  [11:0] sa;
    wire  [11:0] sb;
    wire  [7:0] qwa;
    wire  [7:0] qwb;
15  wire  [7:0] qwa_1;
    wire  [7:0] qwb_1;

//-----
// code:
20  //-----

assign s  = qwa[7:2] + 232;
assign sa = {12{D[11]}}^{D[0],D[1],D[2],D[3],D[4],D[5],D[6],D[7],D[8],D[9],
D[10],D[11]};
25  assign sb = {12{D[12]}}^D[23:12];
    assign qwa_1 = qwa - 1;
    assign qwb_1 = qwb - 1;

DECODER DCA(.D(sa), .Q(qwa));
30  DECODER DCB(.D(sb), .Q(qwb));

always @ (D or qwa or qwb) begin
    if (D[12]^D[11]) begin
        if (qwb[0]) begin
35        QA <= {qwb[7:1],qwa[1:0]};
        QB <= s;
    end
    else begin
        QB <= {qwb[7:1],qwa[1:0]};
        QA <= s;
40

```

```
        end
    end
    else begin
        QA <= {1'b0,qwa_1};
5      QB <= {1'b0,qwb_1};
        end
    end

endmodule
```

10